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ENGINEERING DESIGN FILE

Project/Task Evironmental Restoration/ Historical Data Task (HDT) and Recent and Projected Data Task (RPDT)

Subtask TRA Evaluation

EDF Page 1 of 15

TITLE: Scaling Factors for Waste Activities Measured by G-M Method

SUMMARY

The summary briefly defines the problem or activity to be addressed in the EDF, gives a summary of the activities performed in addressing the problem and states the conclusions, recommendations, or results arrived at from this task.

A new set of scale factors have been derived for use in subdividing gross activities determined from the G-M method into individual nuclide activities in support of the TRA sections of the Historical Data Task and the Recent and Projected Data Task. These new scale factors more accurately account for the activities not measured by the G-M method. The methodology of determining these new scale factors is presented in this document together with a review of the annual waste management reports for shipments from TRA over the period 1973-1982. The impact of using these new scale factors will be to increase the total activity by ≈ x2 over the activity reported from a G-M counter measurement. The scale factors listed in this EDF for dry radioactive waste, resins and sludge waste categories supersede all previous scale factors reported for these waste categories and are the values reported in the current versions of Volume 2 of the HDT and RPDT reports and were used to derive the nuclide breakdowns shown in CIDRA for TRA generated waste shipped to RWMC/SDA.

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1. Introduction:

For many of the radioactive waste shipments from the Test Reactor Area (TRA) to the Surface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC), the total Curie content was measured by the Geiger-Müller (G-M) counter or similar ionization chamber method. (Note! In this document all methods which measure total dose or dose rate will be referred to as the G-M method.) For large waste containers; i.e., larger than a pint sized ice cream container, the response of the G-M method will be dominated by the gamma activity. Unless some other measurement method is used (e.g., small batch sample beta counting) or unless some correction (based on experience or calculations) is applied, the reported activity from a G-M method will not account for alpha emitters, beta emitters and low-energy and/or low-specific-activity gamma emitters.

One of the ways of correcting for the unaccounted activity is to use scaling factors appropriate for the type of operation from which the waste was generated. These scaling factors can be derived from analytical samples taken from the waste stream or by using scaling factors determined for a similar operation. This engineering design file (EDF) document provides a prescription on how to apply scaling factors where the activity was determined from the G-M method for waste shipments coming from TRA. The supporting information for these scaling factors comes from a review of isotopic data reported for waste shipments from TRA to the SDA for the period 1973-1982 [ref.1-10], the scaling factors recommended by the Electric Power Research Institute (EPRI) for commercial power reactors to use in their reports to the Nuclear Regulatory Commission (NRC) [ref. 11-12] and the isotopic information contained in EDF-ER-WAG7-51 [ref.13] The 1973-1982 period of waste shipments from TRA was reviewed because it was in that period that INEL started reporting isotopic activities in their annual reports. The EPRI scaling factors were reviewed because the commercial reactor operations are very similar to test reactor operations at TRA and therefore the scaling factors, particularly the pressurized water reactor data, are the only applicable data readily available.

The review of annual reports of waste shipments from TRA will be covered in Section 2, the review of EPRI scaling factors will be covered in Section 3. The derivations of the recommended scaling factors for TRA waste streams containing resins, dry radioactive waste or sludge are covered in Section 4.

The new scaling factors will differ from those reported in an earlier EDF [ref. 13] where in the earlier report the weighting factors were based on the total activity, including beta emitters, etc. The new factors are to used where the activity is determined from a G-M counter measurement. From 1952 to 1994, any shipment of radioactive waste from TRA where the radioactivity was reported as mixed activation products (MAP), mixed fission products (MFP), unidentified beta gamma (UBG) or total activity and no method of determination was identified, it is assumed that the activity was

measured using the G-M method. Therefore, the scaling factors in this EDF would apply.

2. Review of TRA Shipments from 1973 to 1982

The sources of data for this review are the site wide annual reports for this period [ref. 1-10]. These reports are given in terms of total activity for the year and also total activities are divided into the major isotopic contributions. Listed in Table 1 are the data for TRA for this period.

The major isotopic contribution is from Cr-51 which has a 27.7 day half life. Associated with its decay is a 320 keV gamma ray which is given off in 10.8% of the decays. Because of its relatively short half life, Cr-51 presents no long term risk as far as dose to the general population is concerned. Normally most nuclide-by-nuclide breakdowns of total activities would not contain Cr-51 activities. However, there were cases where an original data entry did identify Cr-51 activity explicitly, in that case the Cr-51 activity included in the original entry was included in the entry to HDT and RPDT data files. Nevertheless, Cr-51 is a gamma emitter and does contribute to the response of a G-M counter measurement (i.e., it has been estimated that, on the average, 13.5% of the G-M counter response is due to Cr-51 activity). Therefore, Cr-51 activity would have to be accounted for in all G-M counter derived activity reports.

The next highest contribution to the total activity is from Co-60 decay. Cobalt-60 has a half life of 5.3 years and for this nuclide decay there are two gamma rays given off (i.e., 1773 keV and 1332 keV) in 99.9% of the decays. Its average contribution to the total gamma activity in TRA waste is 53.5%. If one assumes that half of the unidentified activity listed under "other" (columns 13-15) in Table 1 is Co-60, its contribution to the total gamma activity is increased to $\approx$ 60%.

In some years the Fe-59 activity is significant. It has a half life of 44.5 days and has 1099 keV and 1291 keV gamma rays associated with its decay. The branching ratios for these gamma rays are 56.5% and 43.1%, respectively. Its average contribution to the gamma activity for TRA waste was 17.5%. For the same arguments as used for Cr-51, the Fe-59 activity is not normally included in the HDT and RPDT data files. However, its contribution to the G-M counter response must be accounted for.

The Cs-137 activity is a small contribution to the TRA activity. It has half life of 30.3 years and has a 661 keV gamma ray associated with 85.2% of its decays. Its average contribution to the total gamma activity is 1%. The low activity of Cs-137 indicates that the major source of radioactivity in the TRA shipments is from activation products rather than fission products.

The "other" category of contributions covers a range of nuclide activities, the most significant contribution comes from MAP+MFP in 1982 and this contribution is 97% of the total "other"

contribution over the period 1973-1982. One can assume that at least 50% of this activity is Co-60 and this is the basis for adding 50% of this activity to the declared Co-60 activity as explained above.

There are two sets of averages shown in Table 1. The first average (listed as "Avg") is the arithmetic average per year for each column shown. The standard deviation associated with the arithmetic average ("std") is listed in the next row down from "Avg". The arithmetic average and its standard deviation will be heavily distorted by the high activity years (1976 - 1979) where there was a major disposal of reactor core and loop components. The next category of average is the log mean average (LMA). Associated with LMA is the log mean dispersion upper limit (LMD+) and the log mean dispersion lower limit (LMD-). In the log case the assumption is that the statistical variations follow a log normal distribution. In the EPRI study this was found to be the case for the commercial power reactor scaling factor data [Ref. 11-12] and is expected to be the case for TRA waste as well. The LMA is less affected by the high activity years and is closely related to median yearly activity. The LMD- and LMD+ indicate the probable range of the yearly activities.

The "Avg" for total activity from TRA over this period was 2.0×10^5 Ci/year whereas the "LMA" was 1.2×10^4 Ci/year. In using these two different averages one has to determine the context with which the numbers will be used. For instance, if one is desiring to know how much activity has been shipped to the SDA over a period of years, then the arithmetic average per year would be appropriate. If on the other hand, one is interested for a given year what is the average activity that can be expected to be shipped to the SDA, then LMA would be more appropriate.

3. Review of EPRI Scaling Factors

As explained in an earlier EDF [ref. 13], major sources of scaling factor data for TRA waste shipments are the EPRI reports [Ref. 11-12]. In that EDF, Table 2.4-2 of reference 12 was used as the basis for deriving the scaling factors. That table contains radioactive waste activities listed by isotope and waste category for a typical pressurized water reactor (PWR) operating year. The PWR was chosen for the basis because it is more like the TRA test reactors in operation than are the boiling water reactors. The scaling factors used in reference 13 were derived from the data in reference 12, Table 2.4-2, by taking the average activities in that table and forming activity ratios. Also in reference 12, Tables 3.1-2 to 3.1-9 contain scaling factor LMA's and LMD's arranged according to waste category and reactor type. These scaling factor LMA's and LMD's were determined by first forming each activity ratio data entry and then obtaining the LMA, LMD over the ensembles of activity ratio data. The order used to obtain an ensemble average; i.e., average activities first then form activity ratios (average/ratio approach) versus form activity ratios first then average the ratio data (ratio/average approach), will definitely

affect the result. Although, in most cases the difference between the two results will be within uncertainty/dispersion. The major cause of the difference is the wide variation in absolute activities. The average/ratio approach will be more heavily weighted by the high absolute activity data in the ensemble; whereas, the ratio/average approach will be less influenced by high activity data. Because the ratio/average approach has less dependence on high absolute activity data, it is preferred over the average/ratio approach. Based on this preference, the scaling factor LMA's listed reference 12, Tables 3.1-2 to 3.1-9 should be used over corresponding scaling factors listed in reference 13. In the evaluations that follow there are two sources of ratio data listed; i.e., PWR and PWR2. The PWR data source refers to the scaling factors derived from the activity data from Table 2.4-2 of reference 12 using the average/ratio approach and the PWR2 data source refers to the scaling factor LMA's listed in Tables 3.3-2 to 3.1-9 of reference 12 which were derived by the ratio/average approach. Where available the PWR2 ratio data were used over the PWR ratio data in the derivations that follow.

4. New Scaling Factor Derivations

The basic premise for the derivation of the scaling factors derived in this EDF is that the G-M method response is dominated by gamma activity and for all intents and purposes the beta and alpha activity are not measured. In some cases the beta activity was roughly accounted for by multiplying the activity determined from the G-M method by a x2. However, this procedure was not universally applied and in most cases it was not clear whether this approach was applied at all. In order to be conservative it was assumed that all activities reported as MAP, MFP, unidentified beta gamma or total were measured by the G-M method or by some other gamma only sensitive detectors and that no correction for unmeasured beta activity was applied.

In the following paragraphs the basic approach for deriving the scaling factors is given. To start with T_j is defined as the total activity in sample "j", G_j is the gamma contribution, B_j is the beta contribution and A_j is the alpha contribution. In these definitions it is assumed that a nuclide activity is classified according to its major decay mode. Most gamma emitters are also beta or positron emitters, but if they have a strong gamma emission probability they will be classified solely as gamma emitters. Examples of gamma emitters are: Cs-137, Co-60; examples of beta emitters are: Fe-55, Sr-90; and examples of alpha emitters are: U-235, Pu-239, Am-241. The sum of these contributions must equal the total activity.

$$T_j = G_j + B_j + A_j$$

Also the total activity can be summed over the activity contributions of the individual nuclides.

$$T_j = \sum_i act_{ji}$$

where: act_{ji} is the activity (beta+gamma+alpha) of nuclide "i" in sample "j".

Likewise gamma activity, beta activity and alpha activity can be determined by summing over the individual nuclide activities.

$$G_j = \sum_i act_{ji} * \gamma_i$$

$$B_j = \sum_i act_{ji} * \beta_i$$

$$A_j = \sum_i act_{ji} * \alpha_i$$

where: γ_i is the gamma fraction; i.e., the fraction of the total activity of nuclide "i" attributed to gamma emission. As stated above if a decay mode involves gamma + beta activity, it will be included in the gamma activity.

β_i is the beta fraction; i.e., the fraction of the total activity of nuclide "i" attributed to beta emission. This fraction includes only the decay modes which go by beta transitions with no gamma emission.

α_i is the alpha fraction; i.e., the fraction of the total activity of nuclide "i" attributed to alpha emission. In the case of alpha transitions there may be gamma transitions which accompany these decay modes; however, such transitions will be included with the alpha contribution even though there are gamma transitions.

According to the assumptions stated above, G_j is the partial activity of a sample measured by a Geiger-Müller counter or by some other gamma sensitive instrument.

In order to determine the activities of all nuclides of interest where only partial activity, G_j, is known, one must apply scaling factors. These scaling factors can come from sampling and analyses performed on representative samples, called reference

standards. These reference standards can be a compilation of results from samples taken from the same waste stream at different times; i.e., historical data, or from a compilation of results taken from samples taken from similar operations, e.g., PWR operational sampling data are reasonable substitutes for sampling data for the test reactor operational activity.

A scaling factor for a nuclide "i" is the ratio of its activity in the reference set to the activity of a reference nuclide "m" in the same reference set "r" or it can also be the ratio of the activity of nuclide "i" to the total activity in reference set "r". The latter definition is what was used in the original compilation of the HDT and RPDT data bases. However, that definition has been modified to account for the fact that only gamma activity is actually measured. The logic for determining the new scaling factors is given below.

First comes the selection of the reference nuclide(s). In the HDT and RPDT evaluations for TRA waste three nuclides were chosen; i.e., Co-60, Cs-137, and Pu-239. Cobalt-60 was chosen because it has a very significant contribution to the TRA waste activity and it can be measured by gamma sensitive systems. It is also the nuclide which gives a rough indication of the presence of activation products in the waste. Cesium-137 is also a gamma emitter and has a significant contribution to the activity in TRA waste. It is the nuclide which gives a rough indication of the presence of fission products in the waste. Plutonium-239 is considered the basis for transuranics in TRA waste. It has gamma transitions accompanying its alpha decay but these are usually quite weak and do not significantly contribute to a G-M response. With established reference nuclides and a reference set of activities, "r", a scaling factor, sf_{mi}, can be determined which relates the activity of nuclide "i" with the activity of reference nuclide "m".

$$sf_{mi} = \frac{act_{ri}}{act_{rm}}$$

The next step is to determine the gamma contribution of reference nuclide "m" to the total gamma activity of reference set "r".

$$b_{rm} = act_{rm} * \frac{\gamma_m}{G_r}$$

The activity of nuclide "i" in sample "j" where only G_j is known can be calculated by:

$$act_{ji}=G_j*sf_{mi}*b_{rm}$$

The product of sf_{mi} and b_{rm} is what has been termed the "new scaling factor" in Tables 3 - 5 and is given the symbol W_{ri} in this derivation. Given G_j and W_{ri} one can determine the activity of nuclide "i" in sample "j". As is the case above, the subscript "r" refers to the reference set used to determine W_{ri}.

$$act_{ji}=G_j*W_{ri}$$

4.1 Scaling factors for resins.

Listed in Table 2 are the isotopic activities for ATR resins as identified for ATR Resin Shipment No. 92026 [ref. 14]. A similar table is found in reference 13, but in Table 2 below there has been a column added for the relative gamma activity contribution to total G-M counter response. The activities listed in this column are used as the reference activities for Co-60 and Cs-137 in the new scale factor determinations for resins as shown in Table 3.

Most of the data used in the determination of the new scale factors are the same as in Table 6 in reference 13. The exceptions are the nuclides where PWR scaling factors have been replaced by PWR2 scaling factors and the values of reference activities have been replaced relative gamma activities as explained in the previous paragraph. The values listed in column 6 (New Scale Factor) of Table 3 should be used when converting gross activities (measured by the G-M method) to individual nuclide activities.

4.2 Scaling factors for dry radioactive wastes.

Table 4 contains the scale factor determination for dry radioactive waste where the gross activities (total, MAP, MFP, UBG) were determined by the G-M method. This table is very similar to Table 11 of reference 13. The exceptions are: (1) a number of the PWR scaling factors have been replaced by PWR2 scaling factors (see Section 3) and (2) the reference values for Co-60 and Cs-137 were taken from the gamma activity data associated with data listed in Table 1 as discussed in Section 2 of this document. The values in column 6 (New Scale Factor) of Table 4 should be used when converting gross gamma activities (measured by the G-M method) to individual nuclide activities.

4.3 Scaling factors for sludge wastes.

Table 5 contains the scale factor determination for sludge waste category. These factors are to be used in those cases where the gross activities (i.e., total, MAP, MFP, UBG) were determined by the G-M method. This table is very similar to Table 16 of reference 13. The exceptions are: (1) a number of the PWR scaling factors have been replaced by PWR2 scaling factors (see Section 3)

and (2) the values of the reference activities for Co-60 and Cs-137 have been taken from gamma activities derived from data in Table 2.4-2 of reference 12. The values in column 6 (New Scale Factor) of Table 5 should be used when converting gross gamma activities (measured by the G-M method) to individual nuclide activities.

5. Conclusions and Recommendations

The new scale factors identified in this document should be used where total activities (measured by the G-M method) are to be subdivided into individual nuclide activities. The new scale factors in Tables 3 - 5 have replaced previous scale factors used in the original compilation of the HDT data file for TRA dry radioactive waste and resins and in the first compilation of the RPDT data file for TRA dry radioactive waste, resins, and sludge. The basic premise for these changes is that reported total activities as measured by the G-M method did not account for contributions from beta, and alpha emitters. This document provides a method using new scaling factors which more accurately account for the missing activity. Overall one can expect that the new total activities for the affected waste categories will be a factor of two (2) greater than that reported in the original compilation of the TRA portion of HDT data file and in the first compilation of the RPDT data file.

References:

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13. "TRA Activity Weighting Factors/Physical and Chemical Properties of ^{14}C, ^{99}Tc and ^{129}I", Y. D. Harker, D. W. Akers,

EG&G Idaho Inc., EDF-ER-WAG7-51, October, 1994.

14. "Evaluation of ATR Waste Analyses," E. H. Ottewitte, (unpublished), page 18, Analysis of Wastes Shipped from ATR to RWMC, contains record of resin shipment 92026 as reported in R. N. Beatty letter to L. J. Toomer, RNB-18-92, Sept. 21,1992.

TABLE 1

Review of Annual Waste Management Reports

TRA Isotopic Activity Breakdown

Year	TRA (Ci)	INEL (Ci)	Cr-51 (Ci)	Percent of TRA Total	Co-60 (Ci)	Percent of TRA Total	Ratio of Cr-51 to Co-60	Fe-59 (Ci)	Percent of TRA Total	Cs-137 (Ci)	Percent of TRA Total	Other (Ci)	Percent of TRA Total	Other Isotope	
1973	1.343E+03	3.398E+05	1.055E+03	7.856E+01	1.180E+02	8.786E+00	8.941E+00	1.297E+02	9.657E+00		0.000E+00	1.112E+03	8.280E+01	Cm-244	
1974	7.360E+02	1.977E+04	8.200E+01	1.114E+01	2.060E+02	2.799E+01	3.981E-01		0.000E+00		0.000E+00	4.260E+02	5.788E+01	Zn-65	
1975	3.130E+02	1.381E+04	2.230E+02	7.125E+01	4.250E+01	1.358E+01	5.247E+00		0.000E+00		0.000E+00	4.640E+02	1.482E+02	Pm-147	
1976	2.147E+05	2.188E+05	1.512E+05	7.042E+01	4.451E+04	2.073E+01	3.397E+00	1.865E+04	8.687E+00		0.000E+00		0.000E+00		
1977	6.202E+05	8.240E+05	5.023E+05	8.099E+01	5.577E+04	8.992E+00	9.007E+00	6.197E+04	9.992E+00		0.000E+00		0.000E+00		
1978	9.295E+05	1.119E+06	7.466E+05	8.032E+01	9.062E+04	9.749E+00	8.239E+00	9.215E+04	9.914E+00		0.000E+00		0.000E+00		
1979	8.280E+02	2.437E+05	7.285E+02	8.798E+01	1.760E+01	2.126E+00	4.139E+01		0.000E+00		0.000E+00	4.020E+01	4.855E+00	MAP+MFP	
1980	8.590E+02	1.495E+05	7.842E+02	9.129E+01	9.300E+00	1.083E+00	8.432E+01		0.000E+00		0.000E+00		0.000E+00		
1981	7.670E+03	1.308E+05	7.753E+02	1.011E+01	3.074E+02	4.008E+00	2.522E+00		0.000E+00	3.522E+03	4.592E+01	7.820E+02	1.020E+01	Nb-95	
1982	2.297E+05	5.127E+05	7.978E+02	3.473E-01	1.093E+05	4.758E+01	7.299E-03	2.502E+04	1.089E+01	1.005E+04	4.375E+00	7.874E+04	3.428E+01	MAP+MFP	
Avg	2.006E+05	3.572E+05	1.405E+05	5.824E+01	3.009E+04	1.446E+01	1.635E+01	3.958E+04	4.914E+00	6.786E+03	5.029E+00	1.359E+04	3.383E+01		
std	3.074E+05	3.436E+05	2.521E+05	3.406E+01	4.024E+04	1.358E+01	2.535E+01								
Sum	2.006E+06	3.572E+06	1.405E+06	7.002E+01	3.009E+05	1.500E+01		1.979E+05	9.867E+00	1.357E+04	6.766E-01	8.156E+04	4.066E+00		
gam.energy			3.200E+02		1.173E+03	1.332E+03		1.099E+03	1.291E+03	6.620E+02		1.173E+03	1.332E+03		
gam.branch			1.080E-01		9.990E-01	9.998E-01		5.650E-01	4.320E-01	8.520E-01		9.990E-01	9.998E-01		
gam.contr.	5.609E+01		7.562E+00	1.348E+01	2.998E+01	5.346E+01		9.838E+00	1.754E+01	5.765E-01	1.028E+00	8.128E+00	1.449E+01	sum =	1.000E+02
LMA	1.170E+04	1.845E+05	3.620E+03	3.095E+01	1.025E+03	8.761E+00	3.532E+00	2.252E+04	6.941E+00	6.610E+03	6.188E+00	2.672E+03	3.310E+01		
LMD+	2.417E+05	7.291E+05	8.534E+04	1.689E+02	3.748E+04	2.638E+01	4.246E+01	1.319E+05	9.840E+00	8.405E+03	1.208E+01	2.410E+04	8.311E+01		
LMD-	5.662E+02	4.669E+04	1.536E+02	5.672E+00	2.802E+01	2.910E+00	2.939E-01	3.846E+03	4.896E+00	5.198E+03	3.168E+00	2.964E+02	1.318E+01		
gam contr.	9.920E+01		3.342E+00		1.751E+01			6.920E+00		5.272E+00		6.616E+01			
norm gam			3.369E-02		1.765E-01			6.975E-02		5.314E-02		6.669E-01			
					5.126E-01					1.543E-01					
					6.891E-01					2.075E-01					

TABLE 2
ATR RESINS

ATR RESIN SHIPMENT No. 92026

Beatty, R. N. letter to L. J. Toomer, RNB-18-92, 09/21/92

Nuclide	Activity (Ci)	Activity Normalized to 1 Ci.	Reported or Scaled Activity	Act. rel. to Co-60	Act. rel. to Cs-137	Act. rel. to Pu-239	Gamma Energy (keV)	Gamma Branch	Gamma Contr. (unnorm.)	Gamma Contr. (norm.)
H-3	6.000E-04	4.176E-04	reported	1.744E-03	1.622E-03	9.091E+00				
C-14	7.600E-02	5.289E-02	scaled(a)	2.209E-01	2.054E-01	1.152E+03				
Fe-55		0.000E+00		0.000E+00	0.000E+00	0.000E+00				
Ni-59	1.400E-03	9.744E-04	scaled(a)	4.070E-03	3.784E-03	2.121E+01				
Ni-63	1.400E-01	9.744E-02	scaled(a)	4.070E-01	3.784E-01	2.121E+03				
Co-60	3.440E-01	2.394E-01	reported	1.000E+00	9.297E-01	5.212E+03	1172,1332	2.000E+00	4.788E-01	6.774E-01
Sr-90	3.400E-01	2.366E-01	reported	9.884E-01	9.189E-01	5.152E+03				
Tc-99	1.800E-05	1.253E-05	scaled(a)	5.233E-05	4.865E-05	2.727E-01				
I-129	3.700E-05	2.575E-05	scaled(a)	1.076E-04	1.000E-04	5.606E-01				
Cs-137	3.700E-01	2.575E-01	reported	1.076E+00	1.000E+00	5.606E+03	6.620E+02	8.520E-01	2.194E-01	3.104E-01
Ce-144	9.200E-03	6.403E-03	reported	2.674E-02	2.486E-02	1.394E+02				
Eu-154	8.700E-03	6.055E-03	reported	2.529E-02	2.351E-02	1.318E+02				
Eu-155	3.700E-03	2.575E-03	reported	1.076E-02	1.000E-02	5.606E+01				
U-234		0.000E+00		0.000E+00	0.000E+00	0.000E+00				
U-235		0.000E+00		0.000E+00	0.000E+00	0.000E+00				
U-236		0.000E+00		0.000E+00	0.000E+00	0.000E+00				
Np-237		0.000E+00		0.000E+00	0.000E+00	0.000E+00				
Pu-238	2.600E-04	1.810E-04	scaled(a)	7.558E-04	7.027E-04	3.939E+00				
Pu-239	6.600E-05	4.593E-05	scaled(a)	1.919E-04	1.784E-04	1.000E+00				
Pu-240		0.000E+00		0.000E+00	0.000E+00	0.000E+00				
Pu-241	2.200E-02	1.531E-02	scaled(a)	6.395E-02	5.946E-02	3.333E+02				
Am-241	5.700E-03	3.967E-03	reported	1.657E-02	1.541E-02	8.636E+01				
Cm-242	3.800E-04	2.645E-04	scaled(a)	1.105E-03	1.027E-03	5.758E+00				
Cm-244	1.800E-04	1.253E-04	scaled(a)	5.233E-04	4.865E-04	2.727E+00				
Other(b)	1.146E-01	7.976E-02	reported	3.331E-01	3.097E-01	1.736E+03	3.200E+02	1.080E-01	8.614E-03	1.219E-02
SUM	1.437E+00	1.000E+00							7.068E-01	

(a) Scaled numbers are from unpublished report by E.H. Ottewitte, entitled: "Evaluation of ATR Waste Analysis", Feb.,1994 (Attachment 7)

(b) Other nuclide activities are for Cr-51,Mn-54,Co-58,Zn-65, Zr-95,Nb-95,Cs-134,Ce-141 and Hf-181. Most of the activity is from Cr-51 which is approximately 50% of the total activity reported. However, its contribution to the total gamma signal as measured by a GM counter is less than 5%. Therefore, for normalization purposes the activity listed under other has been reduced by a factor of 10.

TABLE 3
TRA RESINS

NEW SCALE FACTOR DETERMINATION

Nuclide	Source of Relative Activity (a)	Co/Cs/Pu Ref.(b)	(All values are unitless.) Relative Activity	Activity Ref. Value(c)	New Scale Factor	New Scale Factor Normalzed	Ratio New to Old	New Scale Factor based on Co-60 and Cs-137 4.899E-01
H-3	ATR	CS	1.622E-03	3.100E-01	5.028E-04	2.488E-04	5.409E-01	5.079E-04
C-14	PWR2	CO	6.300E-03	6.800E-01	4.284E-03	2.120E-03	3.786E-02	4.327E-03
Fe-55	PWR2	CO	2.900E-01	6.800E-01	1.972E-01	9.758E-02	ERR	1.992E-01
Ni-59	ATR	CO	4.070E-03	6.800E-01	2.768E-03	1.370E-03	1.245E+00	2.796E-03
Ni-63	ATR	CO	4.070E-01	6.800E-01	2.768E-01	1.370E-01	1.245E+00	2.796E-01
Co-60	ATR	CO	1.000E+00	6.800E-01	6.800E-01	3.365E-01	1.294E+00	6.869E-01
Sr-90	ATR	CS	9.189E-01	3.100E-01	2.849E-01	1.410E-01	5.422E-01	2.877E-01
Tc-99	ATR	CS	4.860E-05	3.100E-01	1.507E-05	7.455E-06	5.325E-01	1.522E-05
I-129	ATR	CS	1.000E-04	3.100E-01	3.100E-05	1.534E-05	5.479E-01	3.131E-05
Cs-137	ATR	CS	1.000E+00	3.100E-01	3.100E-01	1.534E-01	5.479E-01	3.131E-01
Ce-144	ATR	CS	2.487E-02	3.100E-01	7.708E-03	3.814E-03	ERR	7.786E-03
Eu-154	ATR	CS	2.351E-02	3.100E-01	7.289E-03	3.607E-03	5.465E-01	7.363E-03
Eu-155	ATR	CS	1.000E-02	3.100E-01	3.100E-03	1.534E-03	5.479E-01	3.131E-03
U-234	ORIGEN	PU	9.200E-02	4.590E-05	4.223E-06	2.090E-06	4.543E-01	4.265E-06
U-235	ORIGEN	PU	2.000E-03	4.590E-05	9.180E-08	4.543E-08	4.543E-01	9.273E-08
U-236	ORIGEN	PU	3.600E-02	4.590E-05	1.652E-06	8.177E-07	4.543E-01	1.669E-06
Np-237	ORIGEN	PU	5.600E-02	4.590E-05	2.570E-06	1.272E-06	4.543E-01	2.596E-06
Pu-238	ATR	PU	3.940E+00	4.590E-05	1.808E-04	8.949E-05	4.475E-01	1.827E-04
Pu-239	ATR	PU	1.000E+00	4.590E-05	4.590E-05	2.271E-05	4.543E-01	4.636E-05
Pu-240	ORIGEN	PU	6.200E-01	4.590E-05	2.846E-05	1.408E-05	4.543E-01	2.875E-05
Pu-241	ATR	PU	3.320E+02	4.590E-05	1.524E-02	7.541E-03	4.436E-01	1.539E-02
Am-241	ATR	PU	8.636E+01	4.590E-05	3.964E-03	1.962E-03	4.562E-01	4.004E-03
Cm-242	ATR	PU	5.760E+00	4.590E-05	2.644E-04	1.308E-04	4.511E-01	2.671E-04
Cm-244	ATR	PU	2.730E+00	4.590E-05	1.253E-04	6.201E-05	4.429E-01	1.266E-04
other(d)	ATR	CO	3.330E-01	6.800E-01	2.264E-01	1.121E-01		
sum					2.021E+00	1.000E+00		

(a) Source of relative activity is either the ATR resin shipment number 92026 (ATR), EPRI 5077 Table 2.4-2 Radwaste Generation in Curies for 1982 for PWR's (PWR), ORIGEN calculation for ATR fuel irradiation (ORIGEN) or EPRI Resins Scaling Factors (PWR2).
(b) Reference activity refers to activity (either Co-60, Cs-137 or Pu-239) which constitute the bases for the relative activities listed in column four.
(c) Activity reference values are taken from normalized activities listed for either Co-60, Cs-137 or Pu-239 in the ATR shipment number 92026.
(d) Other nuclide activities are for Cr-51,Mn-54,Co-58,Zn-65, Zr-95,Nb-95,Cs-134,Ce-141 and Hf-181. (See note (a) on Table 3)

TABLE 4

DRY RADIOACTIVE WASTE

NEW SCALE FACTOR DETERMINATION

(All values are unitless.)

Nuclide	Source of Relative Activity (a)	Co/Cs/Pu Ref.(b)	Relative Activity	Activity Ref. Value(c)	New Scale Factor	New Scale Factor Normalzed	Ratio New Scale Factor to Old Scale Factor	Scale factor based on Co-60 and Cs-137 2.671E-01
H-3	PWR	CO	1.230E-01	6.680E-01	8.216E-02	2.526E-02	4.984E-01	9.455E-02
C-14	PWR2	CO	1.600E-02	6.680E-01	1.069E-02	3.285E-03	3.700E-01	1.230E-02
Fe-55	PWR2	CO	2.900E+00	6.680E-01	1.937E+00	5.955E-01	ERR	2.229E+00
Ni-59	NUREG	CO	8.540E-04	6.680E-01	5.705E-04	1.754E-04	5.039E-01	6.565E-04
Ni-63	PWR2	CO	4.800E-01	6.680E-01	3.206E-01	9.856E-02	3.221E-01	3.690E-01
Co-60	PWR	CO	1.000E+00	6.680E-01	6.680E-01	2.053E-01	4.994E-01	7.687E-01
Sr-90	PWR2	CS	4.600E-03	2.010E-01	9.246E-04	2.842E-04	1.152E-01	1.064E-03
Tc-99	PWR2	CS	8.800E-04	2.010E-01	1.769E-04	5.437E-05	2.850E-01	2.035E-04
I-129	PWR2	CS	2.600E-03	2.010E-01	5.226E-04	1.606E-04	1.954E+00	6.014E-04
Cs-137	PWR	CS	1.000E+00	2.010E-01	2.010E-01	6.178E-02	4.175E-01	2.313E-01
Ce-144	PWR2	PU	1.408E+02	3.330E-05	4.689E-03	1.441E-03	3.021E-02	5.395E-03
Eu-154	NUREG	CO	4.390E-06	6.680E-01	2.933E-06	9.014E-07	5.087E-01	3.375E-06
Eu-155	ORIGEN	CS	4.670E-02	2.010E-01	9.387E-03	2.885E-03	4.113E-01	1.080E-02
U-234	ORIGEN	CS	1.020E-05	2.010E-01	2.050E-06	6.302E-07	4.232E-01	2.359E-06
U-235	ORIGEN	CS	2.220E-07	2.010E-01	4.462E-08	1.372E-08	4.131E-01	5.135E-08
U-236	ORIGEN	CS	4.000E-06	2.010E-01	8.040E-07	2.471E-07	4.158E-01	9.252E-07
Np-237	ORIGEN	CS	6.220E-06	2.010E-01	1.250E-06	3.843E-07	4.205E-01	1.439E-06
Pu-238	PWR2	PU	1.000E+00	5.350E-05	5.350E-05	1.645E-05	2.860E-01	6.157E-05
Pu-239	ORIGIN	U-235	5.000E+02	1.070E-07	5.350E-05	1.645E-05	2.731E-01	6.157E-05
Pu-240	ORIGEN	CS	6.890E-05	8.200E-02	5.650E-06	1.737E-06	1.735E-01	6.501E-06
Pu-241	PWR2	PU	1.100E+02	5.350E-05	5.885E-03	1.809E-03	2.049E-01	6.772E-03
Am-241	PWR2	PU	5.000E-01	5.350E-05	2.675E-05	8.223E-06	2.787E-01	3.078E-05
Cm-242	PWR2	PU	5.100E-01	5.350E-05	2.729E-05	8.387E-06	1.314E-01	3.140E-05
Cm-244	PWR2	PU	4.700E-01	5.350E-05	2.515E-05	7.729E-06	2.701E-01	2.894E-05
other(d)	ORIGEN	CS	5.560E-02	2.010E-01	1.118E-02	3.435E-03		
sum					3.253E+00	1.000E+00		

(a) Source of relative activity is either EPRI NP-5077 Table 2.4-2
Radwaste Generation in Curies for 1982 for PWR's (PWR), ORIGEN2 calculation
for ATR fuel element (ORIGEN), NUREG CR-3474 Activation Products
in 304 Stainless Steel (NUREG), or EPRI NP-5077 Table 3.1-4 DAW Scaling Fac tors (PWR2).
(b) Reference activity refers to activity (either Co-60, Cs-137 or Pu-239)
which constitute the bases for the relative activities listed in column four.
(c) Activity reference values are taken from normalized LMA gamma activities listed
for either Co-60, Cs-137 or Pu-239 in the review of TRA annual reports from 1973-1982.
(d) Other includes Sb-125,Eu-152,Pu-242

TABLE 5
SLUDGE

NEW SCALE FACTOR DETERMINATION

All values are unitless.

Nuclide	Source of Relative Activity (a)	Co/Cs/Pu Ref.(b)	Relative Activity	Activity Ref. Value(c)	New Scale Factor	New Scale Factor Normalzed	Ratio New Scale Factor to Old Scale Factor	Scale Factor based on Co-60 and Cs-137 actvities. 4.422E-01
H-3	PWR	CO	1.210E-01	8.660E-01	1.048E-01	4.633E-02	2.574E+00	1.048E-01
C-14	PWR2	CO	1.200E-02	8.660E-01	1.039E-02	4.595E-03	1.436E+00	1.039E-02
Fe-55	PWR2	CO	8.900E-01	8.660E-01	7.707E-01	3.408E-01	1.175E+00	7.707E-01
Ni-59	RESIN	CO	4.600E-03	8.660E-01	3.984E-03	1.761E-03	2.796E-01	3.984E-03
Ni-63	PWR2	CO	3.700E-01	8.660E-01	3.204E-01	1.417E-01	1.288E+00	3.204E-01
Co-60	PWR2	CO	1.000E+00	8.660E-01	8.660E-01	3.829E-01	2.735E+00	8.660E-01
Sr-90	PWR2	CS	4.800E-03	1.340E-01	6.432E-04	2.844E-04	3.269E-01	6.432E-04
Tc-99	PWR2	CS	7.800E-04	1.340E-01	1.045E-04	4.622E-05	6.797E-01	1.045E-04
I-129	PWR2	CS	3.100E-04	1.340E-01	4.154E-05	1.837E-05	6.560E-01	4.154E-05
Cs-137	PWR2	CS	1.000E+00	1.340E-01	1.340E-01	5.925E-02	1.118E+00	1.340E-01
Ce-144	PWR2	CS	3.140E-01	1.340E-01	4.208E-02	1.861E-02	1.163E+00	4.208E-02
Eu-154	RESIN	CS	2.350E-02	1.340E-01	3.149E-03	1.392E-03	1.071E-01	3.149E-03
Eu-155	RESIN	CS	1.000E-02	1.340E-01	1.340E-03	5.925E-04	1.097E-01	1.340E-03
U-234	RESIN	CS	1.630E-05	1.340E-01	2.184E-06	9.658E-07	1.085E-01	2.184E-06
U-235	RESIN	CS	3.550E-07	1.340E-01	4.757E-08	2.103E-08	1.107E-01	4.757E-08
U-236	RESIN	CS	6.380E-06	1.340E-01	8.549E-07	3.780E-07	1.080E-01	8.549E-07
Np-237	RESIN	CS	9.960E-06	1.340E-01	1.335E-06	5.901E-07	1.093E-01	1.335E-06
Pu-238	PWR2	PU	9.800E-01	3.380E-05	3.312E-05	1.465E-05	6.975E-01	3.312E-05
Pu-239	PWR2	PU	1.000E+00	3.380E-05	3.380E-05	1.495E-05	6.793E-01	3.380E-05
Pu-240	RESIN	PU	6.200E-01	3.380E-05	2.096E-05	9.266E-06	2.725E-05	2.096E-05
Pu-241	PWR2	PU	1.100E+02	3.380E-05	3.718E-03	1.644E-03	5.138E-01	3.718E-03
Am-241	PWR2	PU	4.100E-01	3.380E-05	1.386E-05	6.128E-06	6.128E-01	1.386E-05
Cm-242	PWR2	PU	8.100E-01	3.380E-05	2.738E-05	1.211E-05	5.263E-01	2.738E-05
Cm-244	PWR2	PU	3.800E-01	3.380E-05	1.284E-05	5.679E-06	5.679E-01	1.284E-05
U-238	ORIGEN	PU	8.550E-05	3.380E-05	2.890E-09	1.278E-09	3.651E-04	2.890E-09
sum					2.262E+00	1.000E+00		

(a) Source of relative activity is either EPRI NP-5077 Table 2.4-2
Radwaste Generation in Curies for 1982 for PWR's (PWR), ORIGEN2 calculation
for ATR fuel element (ORIGEN), TRA Resin scaling factors (RESIN) or PWR Scaling factors all data (PWR2).
(b) Reference activity refers to activity (either Co-60, Cs-137 or Pu-239)
which constitute the bases for the relative activities listed in column four.
(c) Activity reference values are taken from normalized activities listed
for either Co-60, Cs-137 or Pu-239 in the EPRI NP-5077 (PWR) Table 2.4-2